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ABSTRACT

Student projects in both research and statistics classes promote active learning and critical thinking not found in more passive types of course delivery. Students start the dialogue of researchers as they internalize the process of conducting research projects with "real world" issues of interest to them in introductions to research and statistics taught at the University of Louisville (Kentucky). In research classes, the content focuses on the processes needed to create an American Psychological Association journal article using both qualitative and quantitative research techniques on a single research problem. The student devises a research plan, completes it with feedback, and learns to write each section of a research paper. In statistics classes, the content is focused on using statistics in writing research questions along with methods and results sections for one research problem chosen by the students. The content is the same as that of most statistics classes except for the continual conceptual emphasis on one research problem. The success of these courses is reflected in positive student enthusiasm for the projects created. Student start to learn the role of researcher or statistician and how to communicate the results of the work through journal-style writing. An appendix contains the Web page for the research course. (Author/SLD)

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Building Conceptual Understanding of Research and Statistical Methods Through Student Projects

Margaret Godwin Jamison

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Building Conceptual Understanding of Research and Statistical Methods through Student Projects

Margaret Jamison
University of Louisville

Paper presented at the Annual Meeting of the Mid-South Educational Association, November 4-6, 1998, New Orleans, Louisiana

ABSTRACT

Student projects, in both research and statistics classes, promote active learning and critical thinking not found in more passive types of course delivery. By working through the research process and completing student projects, the role of the student shifts from receiving course content from an instructor to the student assuming the role as researcher or statistician. Students immediately start the dialogue of researchers as they internalize the process of conducting research projects with "real world" issues of interest to them. To connect students to the role of researcher or statistician, students must always be introduced to the conceptual landscape of the course in the beginning and repeatedly throughout the course.

In research courses, the content focuses on the processes needed to create an APA journal article using both quantitative and qualitative research techniques on a single research problem. First, the course starts with an introduction to the role of the researcher and lists tasks necessary to complete the final research project. Second, the student creates a research resource team complete with content area specialist, librarian, statistician and technology expert. Third, the course quickly moves into how to construct both quantitative and qualitative research questions on the one research problem chosen by the student. Fourth, the research designs are kept simple and uncomplicated with the quantitative research design based on a two-sample study while the qualitative focuses on interviewing and triangulation. Students complete small tasks and are given feedback throughout the course leading to successful completion of their combined research projects. The rest of the course teaches the student, now a researcher, how to complete and write each section of their research paper.

In statistics classes, the content is focused on using statistics in writing research questions along with method and results sections for one research problem chosen by the student. First, the course starts with a conceptual overview of the role of statistics in the research process. Second, the student picks a problem, which can be measured by the many variables needed for the various statistical techniques. Third, content of this statistics course is the same as most statistic courses except for the continual conceptual emphasis on one research problem, which is used to model the many statistical techniques, taught throughout the course. At the end, the student reflects on the type of information learned about their chosen research area from each of these statistical analyses and written project reports. The success of these research and statistic courses is reflected in positive student enthusiasm for the projects created. Not only have they started to learn the role of researcher or statistician, but how to communicate the results of their work through journal-style writing. Completion of these research projects seems impossible at the beginning of the course but each student walks away with the pride and product that truly reflects their ability to do research and statistics.

1. Introduction

For the past decade, there has been a cry to improve education in the teaching of research and statistics course (MAA Notes, Number 26: Statistics for the Twenty-first Century). Many instructors are having difficulties teaching such courses complaining that students "just can't get it". Students are more vocal about such classes calling them "a waste of time" or "the worst course I took in college". There is dissimilarity between the fascination of the instructors about statistical theory and procedures and the dread of students forced to take statistics and research classes because they are required. These

opposites need not occur if both instructors and students share a common interest: the application of research and statistics to real and interesting issues of interest to both. This paper focuses on ways to build conceptual understanding of the process of research and statistics through the use of student projects.

By working through the research process and completing student projects, students shift from learners receiving course content from an instructor to students assuming the role as researcher or statistician. This shift allows both the student and the instructor to share the burden of learning. Students immediately start the dialogue as researchers as they internalize the process of conducting research projects with "real world" issues of interest to them. Student projects, in both research and statistics classes, promote active learning and critical thinking not found in more passive types of course delivery.

The entire course content of the two courses presented here, an introductory research and statistics course and a statistical methods course, is focused on helping students learn research and statistical concepts by applying what's learned in the classroom to their own student projects. Week by week, the course content is taught more like an apprenticeship with the instructor becoming a researcher or statistician showing the students, fellow researchers, how to successfully complete their research projects using the content learned in class. The students see the whole conceptual landscape of the course at the beginning of the course and also as it built upon throughout the course. As each concept is added, the relationship of this concept to the entire conceptual landscape is explained. The students slowly make positive progress toward learning course topics and creating a project that is uniquely theirs. Considering that research and statistics classes draw such diverse audiences, this technique of conceptual understanding plus student projects create the types of classes that instructors enjoy teaching and students will comment "I must be a geek but I like this class".

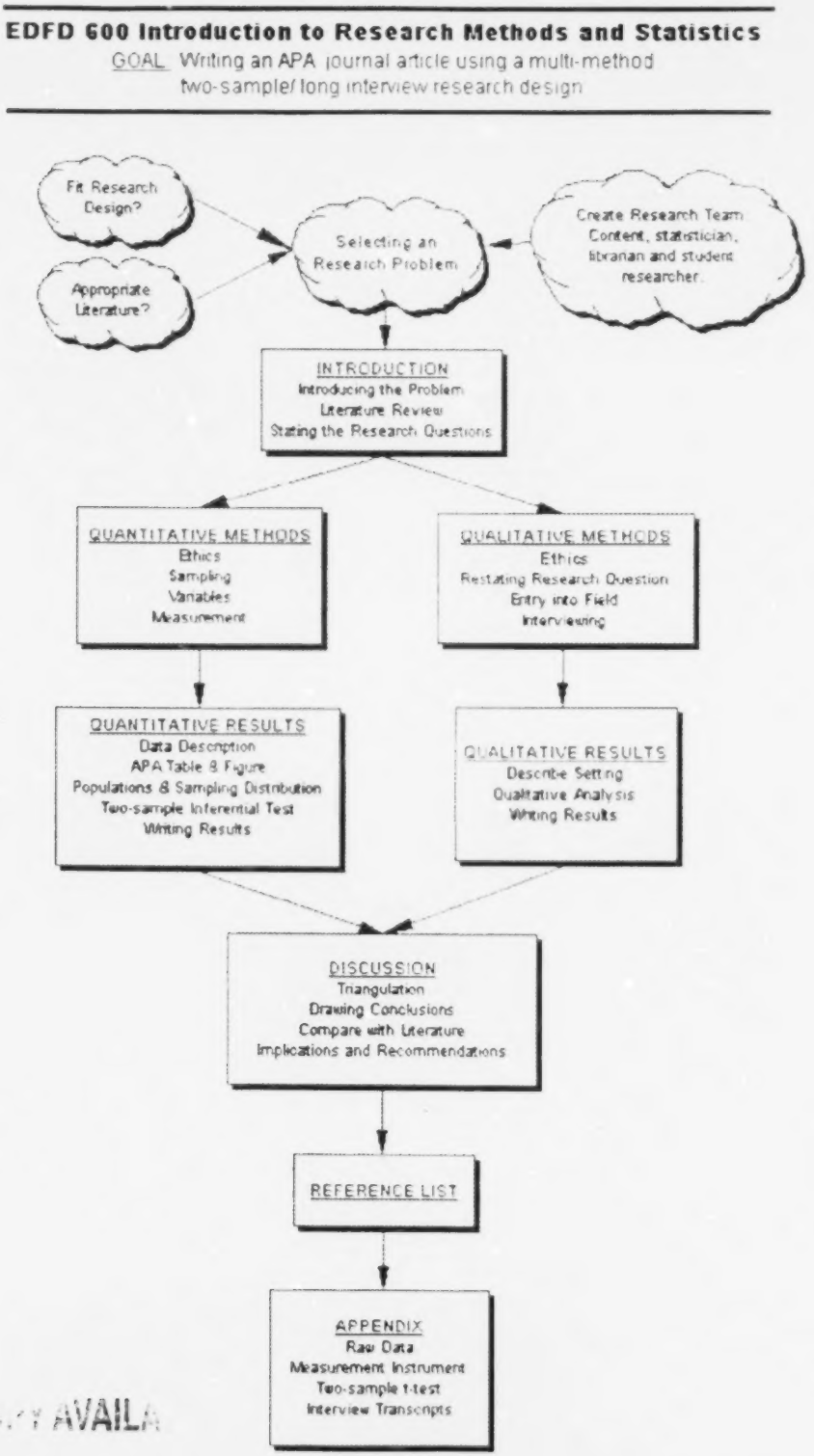
2. Implementation in a Research and Statistics Course

Audience. Introduction to Research and Statistics is a course taught to all masters' students in the School of Education at University of Louisville, Louisville, Kentucky. Other students outside of the School of Education also take this class as it fulfills the requirement for a research course in many programs. Most of the students are only taking this course because they are forced to do so. Interest is low and the usefulness of the class is always in question. Because of these reasons and the diverse audience, this course was redesigned to change these attitudes and involve the student in actively learning the course material through student projects.

Conceptual Landscape. Starting with the first class meeting, students are introduced to an overview of the entire course, as it will be presented throughout the semester. The course blends the research and statistical course content with the processes needed to create an APA journal article using both quantitative and qualitative research techniques on a single research problem of interest to the students, which is their student project. The student in creating their own journal article uses every concept taught in class. A flowchart of research and statistical concepts integrated into a student-generated journal article is presented in Figure 1.

Class Content and Procedures. The course starts with an introduction to the role of the researcher and the importance of research in understanding problems and questions. Statistics, the language of data, is shown as a way to understand and communicate answers to research questions and problems. The students are introduced to the concept map of the class and shown what their role will be in learning research and statistics for this course. Students start their role as researcher immediately by creating a research resource team consisting of a content area specialist, librarian, statistician and technology expert. For my classes I am the statistician and help as a technology expert as well. The content area specialist can come from an academic department or an expert from the data collection site. The librarian is a research librarian from the university library assigned to our department. Further assistance in technology comes from the Educational Resource Technology Center and Information Technology Center. Lines of communication are set up between the student and members of their research resource team. My form of communication with the students is classroom contact, office hours and email. Once the research team is established, the student starts to consider possible research problems he or she would be interested in pursuing.

Figure 1. Flowchart of concepts integrated into a student-generated journal article for an introductory research and statistics course.



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A detailed description of the course content as it is taught each week is presented in Appendix A at the end of this paper along with the web address to access the course web page. The student is first taught how to construct both quantitative and qualitative research questions, which could be investigated and answered using the research design, implemented by the statistician (the instructor). The research design used for this class is a quantitative two-sample study followed up with a qualitative interview. For the quantitative two-sample study, the students choose a continuous numerical variable that can be measured on two samples as determined by the research problem. The students will triangulate their research problem a second time using a qualitative interview. Certain restrictions have to be implemented to keep the time frame of the study within a semester. Each of the two samples has to have 20 or more observations and the student will interview 2-4 people.

As the student is conceptualizing and operationalizing how they will complete their study, the students are introduced simultaneously to the scientific method of research and parts of an APA research journal article. It is explained to the students that writing the journal article is the form of communication a researcher would use to explain the results of their study. The entire course is focused around the parts of the journal article: Introduction, Methods, Results, Discussion, Reference List and Appendix. The execution of each section of a journal article conforms to the scientific method of research. Every week a section of a journal article is under study. The research and statistics concepts are taught as needed in the execution of a study. A research study concerning faculty salaries is the example modeled throughout the course by the instructor. After the instructor explains the research and statistics concepts needed to execute each section of the research paper, the student is required to do the same to his or her own study. Any questions or concerns are addressed to members of the research resource team.

The concepts taught in the Introduction section focus on the three parts of this section: introducing the problem, a literature review and a statement of the research questions. The instructor and the librarian teach the students how to search for articles to be used in the literature review. The librarian, one of the members of the research resource team, teaches using the Internet and library database resources to locate possible resources for the literature review. How to cite references using APA format and evaluating web sites as possible literature review references is also explained. By the time teaching this section is completed the students have had time to finalize the quantitative and qualitative research questions used in their own research questions.

The focus of teaching for the Methods section is to operationalize the procedures of data collection. A certain amount of terminology is covered such as quantitative and qualitative data, categorical, discrete and continuous variables, samples and populations. Measurement validity and reliability come up in understanding the numerical and categorical variable under study. Before data collection can begin, the students are bound by guidelines of a student contract approved by the college Human Studies Committee signed by both them and the instructor. Once the data is collected, the students have to present the data by creating an Appendix table that contains the data in two-sample format. The focus on writing the Methods section is on each of the three sections: Participants, Materials and Design and Procedures.

Five weeks of statistics are needed to teach how to construct a Results section and complete the statistical analysis. The four statistical concepts are graphical data description, numerical data description, theoretical distributions and the inferential two-sample t-tests. The student creates an APA-formatted figure of the two histograms, one for each sample. A descriptive APA-formatted table explains measures of middle and spread. An explanation of how to write comparative sentences to explain both the figure and table are taught along with the statistical procedures. Use of a scientific calculator to compute statistical functions is used for the statistical computations. Sample histograms, population smooth histograms, sampling distributions along the transformed t- and z- distributions are introduced and explained as to how they relate to the inferential test needed to answer the research question. Both the dependent and independent two-sample t-tests are taught as students could use one or the other of these types of tests on their two-sample studies. The answer to research questions is finalized and conclusions drawn from hypothesis testing. Since the computation of the two-sample test statistics can be rather complicated, checking their computations using Microsoft Excel is explained. By the end of these five weeks, after a review and statistics test on these procedures, the students have learned enough statistics to feel confident that their Results section is correct. Constant feedback in the form of corrections is given by the instructor to make sure the figure, table and steps of hypothesis testing are

correct. The writing of the Discussion section is explained and students turn in the Quantitative APA-formatted journal-style research paper.

The last three weeks of the semester are focused on re-examining their research problem using a qualitative research technique. Before starting the qualitative data collection, an exploration into the issues of triangulation and how a qualitative research method would enhance their results is introduced. This not only gives them a form of comparison but also cuts down the time spent on thinking up a new research problem to study. An overview of what qualitative research is how it differs from quantitative research and what are common techniques of qualitative data collection is explained. Interviewing techniques, as outlined in the book, The Long Interview (McCracken, 1988), form the basis for the qualitative data collection. Again students are reminded of the student contract containing ethical research guidelines signed at the beginning of the semester.

The focus of the Qualitative Methods section is the creation of the qualitative questionnaire, which helps the student focus their questions asked to the 2-4 people interviewed. The questions consist of biographical and grand tour questions as presented in the McCracken book. Students are also required to write descriptive paragraphs describing the social setting for each of the people interviewed. Transcripts of the interviews and the descriptive paragraphs are the collected qualitative data. The advantage of showing the students, the whole conceptual landscape of the course, pays off big dividends in this type of research. They have already completed a literature review looking for possible factors affecting their numerical variables so they have already started to consider the possible categories for their qualitative data analysis. At the very least, they have been looking for clues and circumstances, which will help them with their qualitative data analysis. The students write a Qualitative Methods section which is inserted after the Quantitative Methods section created above again focusing on the same three Method sections: Participants, Materials and Design and Procedure.

By working with transcripts and descriptive paragraphs, the students create a Qualitative Results section. They will look for data that supports the categories set up by the literature review or personal experiences with the quantitative study. Researcher biases are also addressed in the Qualitative Results section as their own personal beliefs and biases certainly are the filters for their interpretation. The Qualitative Results section is added after the Quantitative Results section. Students finish the final Quantitative/Qualitative journal article by expanding the Discussion by adding the new knowledge and insight gained by the qualitative study. An abstract of the whole study is added to the finished research paper.

Instructor Issues. Several teaching issues come up in teaching a project-based class:

- How do I personally work with each student on their research paper in a timely fashion especially in large classes (this class has 35-40 students per class)?
- How do I focus each student into selecting not only an appropriate research problem but also one, which will fits the two-sample design?
- How do I grade the Quantitative and Quantitative/Qualitative journal-style papers?
- How do I measure conceptual understanding of research and statistical methodology?

All of these issues have to be addressed by an instructor who teaches in this type of learning environment.

3. Implementation in Statistical Methods Course

Audience. A single statistic course, Applied Statistics, is used to teach introductory statistics to doctoral students in the School of Education at the University of Louisville. An overview of all statistical procedures appropriate for use in dissertation and master's thesis are supposed to be presented in this one course. The majority of the students in this class are doctoral students coming from either the Counseling and Psychology or the Adminstrative programs. The students in this class are more focused in this class because they know there is a need to know almost all of what they will learn in order to pass comprehensive exams and write dissertations. The audience for this course is very different from the

Introduction to Research Methods and Statistics taught to incoming Master's students discussed previously.

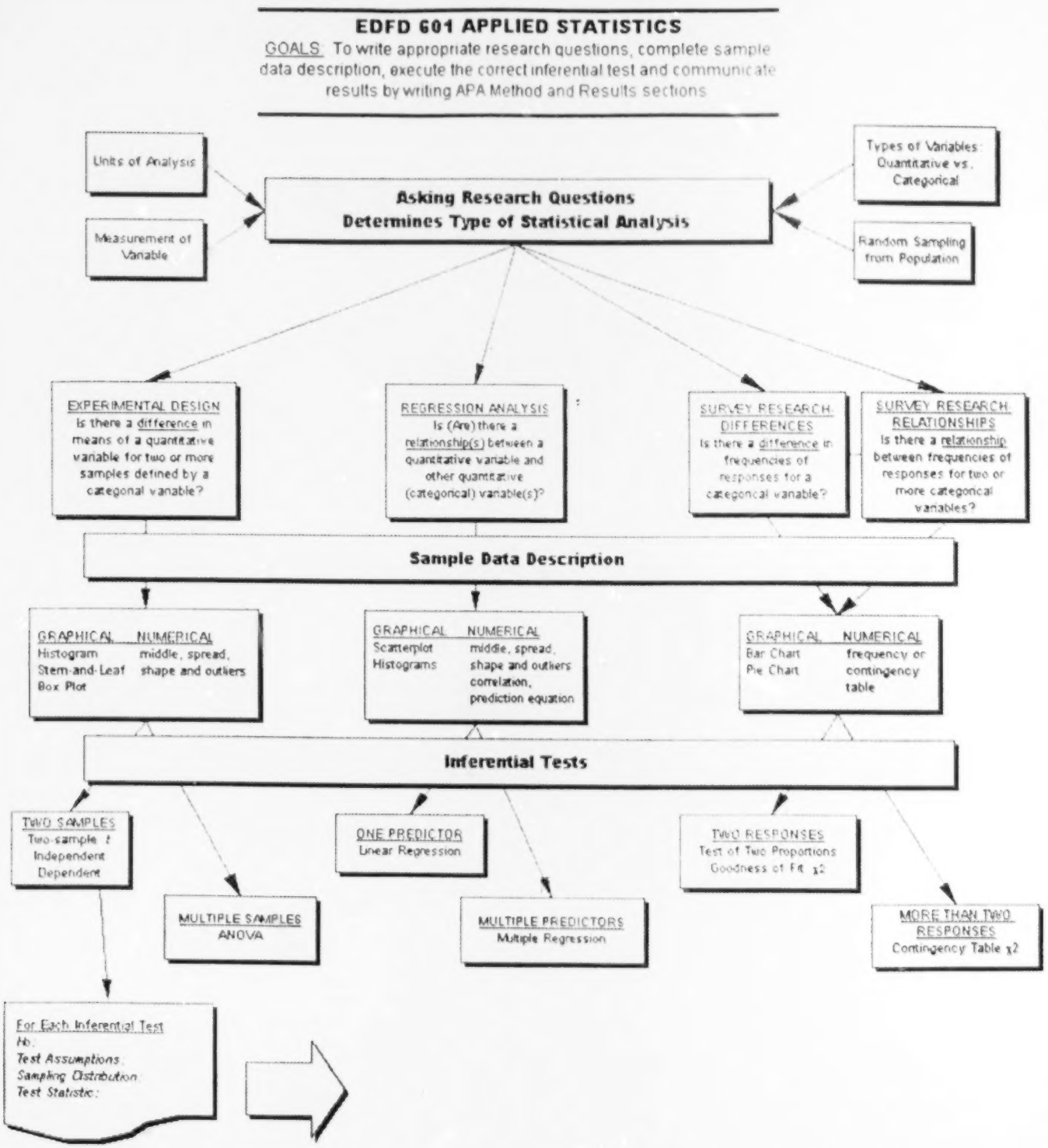
Conceptual Landscape. Since only an overview of statistics can be taught in such a short time frame as a one semester course, the use of the conceptual landscape is critical to success in this course. Instead of teaching one statistical procedure after another as is the format of all statistics books, this course teaches the four course objectives for the three general types of statistical analyses: experimental design (means), regression analysis (relationships) and survey research (frequencies) simultaneously. The conceptual landscape for the course is 1) to write appropriate research questions, 2) complete sample data description, 3) execute the correct inferential test and 4) communicate results by writing APA Method and Results sections. The students build a statistical portfolio on one research problem completing each of the four concepts on the three types of statistical analyses.

Class Content and Procedures. The course starts with an introduction into the role of a statistician: what is statistics, statistical terminology, scientific method of research, how to ask appropriate research questions and use of technology. Immediately the students start their role as a statistician by being introducted to the one research problem area all of them will investigate throughout the whole semeter. Because coming up with an appropriate research problem to study is too time-consuming , this course will focus on one research problem area chosen by the instructor. Since several types of research questions are used in teaching statistical methods classes, the data set must be complex enough to answer all types of research questions in the three general areas of statistical analyses. Because this course is taken by mostly doctoral students who must write dissertations, the research problem is stress management. Previous surveys in other research classes have shown that graduate students, especially in education, are trying to juggle both a job in the daytime and persue a graduate degree in the evening. A large percent of these students have expressed an interest in workshops geared toward stress management. By choosing a single topic, each student could then talk to other students about results and possible strategies to insure success in data analysis. A speaker could also be brought in who could discuss the topics of stress, burnout and health issues.

The second week of class would be devoted to creating the research questions on stress management generated by the students and determine how each of these research questions could be analyzed using one of the three areas of statistical analysis-experimental design (means), regression (relationship) and survey (frequencies). A single data collection instrument would be generated. Decisions would be made by each student as to what populations they were interested in studying. Each student would be required to administer this data collection instrument according to ethical guidelines contained in the document called Student Contract for EDFD 601 Class Exercises to the samples of interest to the student. This single data set would generate all the data needed for the statistics portfolios required throughout the semester. The flowchart of statistical concepts taught in this course is presented in Figure 2.

The next section of the course focuses on sample data description both graphical and numerical techniques. The instructor models all statististical analyses throughout the semester with a single complex data set generated on another research problem in the area of classroom research of interest to educators. Students complete classwork on the instructor's data set and work on their own portfolio assignments using the techniques learned in class. The appropriate graphical description for experimental design of testing two or more sample means is the creation of histograms, stem-and-leaf display and boxplots for each sample studied. The numerical data description for experimental design is the measures of the middle, spread, shape and outlier. After explaining data description for experimental design, data description of research questions using regression, or relationships, is taught. The graphical data description for linear regression is the scatterplot while the numerical data description is the measure of the correlation coefficient, coefficient of determination and estimation of the least squares prediction equation. Finally data description is focused on counts of categorical variables for either measuring differences of one categorical variable or measures of relationships between two categorical variables. Graphical data description for categorical variables is the bar and pie chart while numerical data description consists of creating frequency or contingency tables. Once the section on sample data description is complete, the student's portfolio on sample data description for the stress management data set is due. The student communicates the results of his or her analysis through an APA Method and

Figure 2. Flowchart of statistical concepts taught in an introductory statistical methods course.


EDFD 601 APPLIED STATISTICS
GOALS: To write appropriate research questions, complete sample data description, execute the correct inferential test and communicate results by writing APA Method and Results sections
Units of Analysis
Measurement of Variable
Asking Research Questions
Determines Type of Statistical Analysis
Types of Variables: Quantitative vs. Categorical
Random Sampling from Population
EXPERIMENTAL DESIGN
Is there a difference in means of a quantitative variable for two or more samples defined by a categorical variable?
REGRESSION ANALYSIS
Is (Are) there a relationship(s) between a quantitative variable and other quantitative (categorical) variable(s)?
SURVEY RESEARCH: DIFFERENCES
Is there a difference in frequencies of responses for a categorical variable?
SURVEY RESEARCH: RELATIONSHIPS
Is there a relationship between frequencies of responses for two or more categorical variables?
Sample Data Description
GRAPHICAL: Histogram, Stem-and-Leaf, Box Plot
NUMERICAL: middle, spread, shape and outliers
GRAPHICAL: Scatterplot, Histograms
NUMERICAL: middle, spread, shape and outliers, correlation, prediction equation
GRAPHICAL: Bar Chart, Pie Chart
NUMERICAL: frequency or contingency table
Inferential Tests
TWO SAMPLES: Two-sample t, Independent, Dependent
MULTIPLE SAMPLES: ANOVA
ONE PREDICTOR: Linear Regression
MULTIPLE PREDICTORS: Multiple Regression
TWO RESPONSES: Test of Two Proportions, Goodness of Fit χ2
MORE THAN TWO RESPONSES: Contingency Table χ2
For Each Inferential Test
Ho:
Test Assumptions:
Sampling Distribution:
Test Statistic:

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Results sections. The Method section included the traditional sections on Participants, Materials and Design and Procedure. The design and procedure section of the Method sectio is enhanced with each statistical analysis.

Once the section on data description is complete, a short unit on population and sampling distributions is introduced. This topic is continued and integrated into the section on inferential testing. The inferential tests are the continuation of the statistical analysis for each of the three types of analyses. For every inferential test taught, there has to be a structure of decision making such that a student knows how to start with any research question and complete the necessary steps to making correct decisions. These decision should not only lead them to the correct conclusions but to understanding the processes and reasoning for each inferential test. These five steps work for each inferential test: 1) State the research question appropriately with variables used in the analysis. This has already been done by completing the sample data description. 2) Set up the hypotheses, both the null and alternative, addressing the theoretical issues of errors and test assumptions. 3) Compute the test statistic (derived from the sampling distribution of the parameters to be tested) using sample statistics. 4) Compare the test statistic generated from sample data with the theoretical critical values of the sampling distribution (sometimes transformed). 5) Draw conclusions.

The inferential tests for experimental design, testing of means, are the two-sample dependent t-test, two-sample independent t-test and ANOVA. After the section is covered on these three inferential tests, students turn in the portfolio from the stress managament data set focusing on answering research questions on differences in two or more means. These results are added to the Results section obtained from sample data description. The Method section is enhanced under the Design and Procedure section to include an explanation of each inferential test used. The second section on inferential tests is concerned with measuring relationships (regression) with the inferential tests focusing on testing the correlation coefficient and partitioning variation due to the linear model by ANOVA. After this section is completed, the students again turn in the portfolio on stress management including the results of these analyses. The last section on inferential testing deals with analysis of categorical variables using the test of two proportions, Chi-square Goodness of Fit test and testing contingency tables. The last assignment of the student portfolio is to include analysis of these types of variables testing both differences in responses of one categorical variable and relationships between two categorical variables in the Results section. Again the Design and Procedure section of the Method section is enhanced by including these types of inferential tests.

At the end of the course, the student has completed a statistics portfolio that demonstrates his or her ability in using statistics to complete data analysis. A review of the conceptual landscape of the course lets the student step back from all the procedures used in these statistical analyses and, hopefully, understand not only what statistics is but the role of the statiscian and the researcher.

Instructor Issues. Several teaching issues come up in teaching a portfolio-based class:

- How do I personally work with each student on his or her statistics portfolio?
- How do I measure the level of competence of each student in statistical methodology using these portfolios?
- Can students come to appreciate statistics and feel positive about the experience?
- Will this type of learning transfer to success in competency exams and in writing dissertations?

All of these issues have to be addressed by an instructor who would teach using this portfolio method as a vehicle for learning in statistics classes.

4. Conclusions and Suggestions for Improvement

The success of these research and statistic courses is reflected in positive student enthusiasm for the projects created. Not only have they started to learn the role of researcher or statistician, but how to communicate the results of their work through journal-style writing. Completion of these research projects or portfolios seems impossible at the beginning of the course but each student walks away with the pride and product that truly reflects their ability to do research and statistics.

Appendix A

Course Web Page for EDFD 600
(http://www.louisville.edu/edu/edfd/EDFD600)

EDFD 600
Intro to Research Methods & Statistics

Course Content | Course Info | Technology | Sample Tests | Research Papers | Discussion

Course Content

Why do Research?

Week 1

[Introducing EDFD 600, Course in Research][Structure of Research]
[Scientific Method][Resources and Technology of a Researcher]
[Concept Map of Course][Newsletter for Graduate Students]
[School of Ed Departments][Graduate Student Handbook]
[Educator Resources][Concept Map of Course]

APA Style and Completing a Research Project

Week 2

[Email][Selecting a Research Problem][Ed Research Syntheses]
[Decisions][PowerPoint Outline][Completing Research Projects]
[Stating Research Questions][Concept Map of a Research Study]
[Parts of an APA Research Paper][Sample Journal Article]

Introduction Section of a Research Paper

Week 3

[Introducing the Research Problem][Completing the Literature Review]
[Using the Internet to Search Library Databases][UofL Research Center]
[Online Interlibrary Loan Forms][AskERIC][UnCover]
[Citing References using APA][Jump Start Your Online Research]
[Evaluating Web Sites][Writing the Introduction Section]

Methods Section of a Research Paper

Week 4

[Quantitative vs. Qualitative Data][Types of Variables]
[Samples and Populations][Generating Random Samples]
[Ethical and Legal Obligations][Collecting Data]
[Measurement Reliability][Measurement Validity]
[Example of a Two Sample Data Set][Writing the Methods Section]
[Sample Methods Section][Guidelines for Research Proposal]

Results Section and Graphical Description of Quantitative Data

Week 5

[Descriptive vs. Inferential Statistics][HyperStat Online]
[Describing Univariate Data][Drawing a Histogram]
[Comparing Two Histograms][Creating Figures in APA Style]

Results Section and Numerical Description of Quantitative Data

Week 6

[Measures of Center] [Measures of Variability]
[Using the Calculator to Compute Statistical Functions]
[Skewness][Creating Tables in APA Style]
[Web Pages Performing Statistical Calculations]

Results Section and Normal Populations

Week 7

[Z-scores][Empirical Rule] [Outliers]
[Writing the Descriptive Part of the Results Section]
[Normal Distributions and Properties][Functions and Areas under a Curve]

Results Section and Sampling Distributions

Week 8

[Sampling Distributions][Handout][Standardized z- and t- Distributions]
[Central Limit Theorem][Point Estimators][Hypothesis Testing]
[Two Sample Problems][Independent vs. Dependent Samples]
[Testing Two Dependent Means]

Results Section and Two-Sample t-tests for Means

Week 9

[Testing Two Independent Means][Statistical Significance in Results Section]
[Using Excel for Two-Sample Tests for Means][Salary][Sample Stat Test]

Discussion Section and Review

Week 10

[Review Hypothesis Testing][Writing the Inferential Part of the Results Section]
[Writing the Discussion Section][Sample Results Section]
[Sample Discussion Section][Guidelines for Quantitative Paper]

Week 11

Test on Descriptive and Inferential Statistics

Week 12

Triangulation of Research Question Using Qualitative Research

[Restating the Qualitative Research Question][Triangulation]
[Comparison of Quantitative and Qualitative Research][PowerPoint Outline]
[Overview of Qualitative Research][The Long Interview]
[Questionnaire Construction][Biographical Questions][Grand Tour Questions]

Week 13

Qualitative Methods Section

[Observing the Social Setting][Prompts][Interview Process][Data Collection]
[Taping the Interview][Data Transcription]

Week 14

Qualitative Results Section

[Categories Supported by Data][Support or Discovery][Researcher's Biases]
[Re-visiting Journal Article][Validity and Convergence of Two Research Designs]
[Guidelines for Final Paper][Review Concept Map for Course]

Finals Week

Final Quantitative and Qualitative Paper Due

School of Education

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